A STATISTICAL METHOD FOR STUDYING THE RADIATIONS FROM RADIOACTIVE SUBSTANCES AND THE X-RAYS AND ITS APPLICATION TO SOME γ-RAY PROBLEMS

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Statistical methods of studying X-rays and the radiations from radioactive substances are important partly because they make it possible, to some extent at least, to investigate the individual rays. The scintillation method of counting α-particles for example brought decisive evidence of the atomic structure of matter. It also made it possible to obtain directly the charge on an α-particle. Furthermore, the experiments on the scattering of α-particles gave Rutherford some definite knowledge which led to some of the most fruitful suggestions about atomic structure.

The electrical method of counting α-particles as used by Rutherford and Geiger was adapted by Geiger,[1] after some changes, to the statistical study of both α-particles and β-particles. Kovarik and McKeehan[2] applied the method to the investigation of the absorption and scattering of β-particles getting direct information about the β-particles, whereas the previous information was all deduced from ionization experiments which to be accurate demands a complete knowledge of the variation of the speed and of ionization with speed of a β-particle passing through matter. By this method they also obtained evidence[3] supporting the single scattering theory of Rutherford and got results in agreement with those deduced from Wilson's photographs of the tracks of β-particles produced by the condensation method—another important statistical method. They also investigated the magnetic spectra[4] of the β-particles from radium B and C and from radium D and E. In their first report they called attention to the fact that the γ-ray effects were also counted and that correction had to be made for these.

A more recent development[5] in the method makes it possible for each ray, upon entering the counting chamber, to cause an audible sound or to make an automatic record on paper. The counting chamber generally surrounds a specially prepared point. The chamber and the point are at a high difference of potential—near the sparking potential. When any of the rays enter the counting chamber, ionization is produced and on account of the intense field between the point and the chamber, ionization by collision results. This magnifies the effect initially produced by the ray and this is further magnified by an audion bulb operating a sensitive relay which operates a local circuit by means of which a chronograph pen makes a record of the fact that an α-particle, a β-particle, a γ-ray pulse or an X-ray pulse has entered the counting chamber.

Using this method it is possible to investigate some important problems

pertaining to the nature of γ-rays and X-rays, and also questions bearing on energy absorption and emission by an atom. For example it is important to know whether a spherical wave passing over matter will cause a simultaneous ejection of electrons at different parts of the same wave front. To test this two independent counting chambers were placed at equal distances from the source of γ-rays but at various different relative positions. One chamber registered the γ-ray effect audibly and the other optically. It was found that in no case were the effects produced simultaneously. When the chambers were placed one behind the other the effects were also non-simultaneous.

By varying the distance between one chamber and the source a confirmation of the inverse square law was obtained. Using a chamber of some definite material with thin walls and increasing this small thickness of the walls the registered number of effects increased. When material of higher atomic weight was used the effect also increased.

The first experiments mentioned can best be explained by assuming some corpuscular or ether-string theory and applying the law of probability to the distribution of the radiations, but in view of the facts coming from crystal experiments it seems necessary to consider some spreading pulse theory. If we assume the pulses to spread out as spherical surfaces we must consider absorption of energy by an atom and also a possible trigger action—an action not in great favor in recent years. The fact that the counting chambers did not record the γ-ray effects simultaneously means that the electron or electrons ejected were not ejected simultaneously from the metal or air of the chamber; but since the electrons ejected have, presumably, equal velocities and, therefore, equal energies, the experimental result indicates that the individual electrons do not acquire the necessary quanta of energy at the same time. This suggests a possible storing up of energy. There are, however, reasons to believe that the energy stored up cannot be equal to the energy represented by the ejected electrons, and it would follow that some if not most of the energy of the ejected electrons must come from the interior of the atom and that the γ-ray energy absorbed is only sufficient to perform the trigger action. Furthermore, it seems very probable that the particular electron to be ejected may have previously acquired, in some way, energy nearly sufficient to throw it out of balance which the γ-ray energy may suffice in doing; and it also seems probable that the more penetrating the γ-rays, i. e., the higher the value of ν, the deeper is the electron which will be ejected by the γ-ray.

During the progress of these experiments, which were to include also the determination of the number of γ-ray pulses per second, per gram of radium, I received reprints of work done on this problem by R. W. Lawson and V. F. Hess[6] at the Radium Institute in Vienna (where Mr. Lawson, although a civilian prisoner during the war, was permitted to continue

his work). Their counting chamber was a Rutherford and Geiger's spherical chamber with gas at reduced pressure. They obtained 2.92 $\times$ 10^{10} γ-rays from radium B and C per second per gram of radium. The material of their counting chamber was copper. In view of my results with chambers of different materials I decided to continue my experiments on this point especially as my results indicated that Lawson and Hess's value is probably low. My results at present indicate a value of 7 $\times$ 10^{10} γ-rays from radium B and C per second per gram of radium.

[1] Geiger, H., *Verh. D. Phys. Ges.*, **15**, 1913 (534).
[2] Kovarik, A. F., and McKeehan, L. W., *Physik. Z.*, **15**, 1914 (434).
[3] Kovarik, A. F., and McKeehan, L. W., *Physic. Rev.*, N. S., **6**, 1915 (426).
[4] Kovarik, A. F., and McKeehan, L. W., *Ibid.*, **8**, 1916 (574).
[5] Kovarik, A. F., and McKeehan, L. W., *Ibid.*, **13**, 1919 (272).
[6] Hess, V. F., and Lawson, R. W., *Sitzb. Akad. Wien*, **125**, 1916 (585).

ON THE NATURE OF THE HEAT PRODUCTION IN A SYSTEM OF PLATINUM BLACK, ALCOHOL, AND AIR

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When a small quantity of platinum black is introduced into an atmosphere of air saturated with ethyl or methyl alcohol vapor a violent reaction takes place on the surface of the platinum causing it to become incandescent.

The nature of this reaction has been explained in two ways. It is held by some that owing to the vast surface and poor heat conductivity of platinum black the adsorption of the alcohol vapor liberates sufficient heat to raise the temperature of the platinum considerably. This rise in temperature is supposed to accelerate the rate of oxidation of the alcohol vapor in the neighborhood of the platinum thus further raising its temperature until the substance becomes incandescent.*

On the other hand it is held by others that the heat produced at the surface of the platinum black is due primarily to the oxidation of the alcohol at the surface of the platinum. The adsorption of the alcohol is in this case considered as contributing relatively little heat. The surface of the platinum is, however, supposed to exert a "catalytic" action on the alcohol vapor and oxygen increasing the speed of reaction to many times that in air at ordinary temperatures.

The writer's attention was called to the two explanations by Prof. Millikan and it occurred to the writer that a decision between the two explanations might easily be obtained experimentally. If a thermocouple

* This explanation is ascribed to Wilhelm Ostwald by Prof. P. Sabatier, in a course of lectures given students of the A. E. F., at Toulouse, France, in 1918.